The receiver shall then wait until the superframe counter equals the value specified in the bit swap acknowledge message. Then, beginning with frame 0 of the next ADSL superframe the receiver shall:

- Change the bit assignment of the appropriate subcarriers and perform tone reordering based on the new subcarrier bit assignment.
- Update applicable receiver parameters of the appropriate subcarriers to account for a change in their transmitted energy.

NOTE – A new bit swap request shall only be sent after the previous bit swap has taken place or when the 500 ± 20 ms timeout has occurred while waiting for a bit swap acknowledge.

11.2.7 Bit swap – Transmitter

After transmitting the bit swap acknowledge, the transmitter shall wait until the superframe counter equals the value specified in the bit swap acknowledge. Then, beginning with frame 0 of the next ADSL superframe, the transmitter shall:

- change the bit assignment of the appropriate subcarriers, and perform tone reordering based on the new subcarrier bit assignment;
- change the transmit energy in the appropriate subcarriers by the desired factor.

If the transmitter receives a new bit swap request message while waiting, it shall immediately stop waiting and update the superframe counter for bit swap according to the new message. It shall restart the process for the newly arrived bit swap request message assuming that the new message equals the previous.

ANNEX A

Specific requirements for an ADSL system operating in the frequency band above POTS

This annex defines those parameters of the ADSL system that have been left undefined in the body of this Recommendation because they are unique to an ADSL service that is frequency-division duplexed with POTS.

A.1 ATU-C Functional Characteristics (pertains to clause 7)

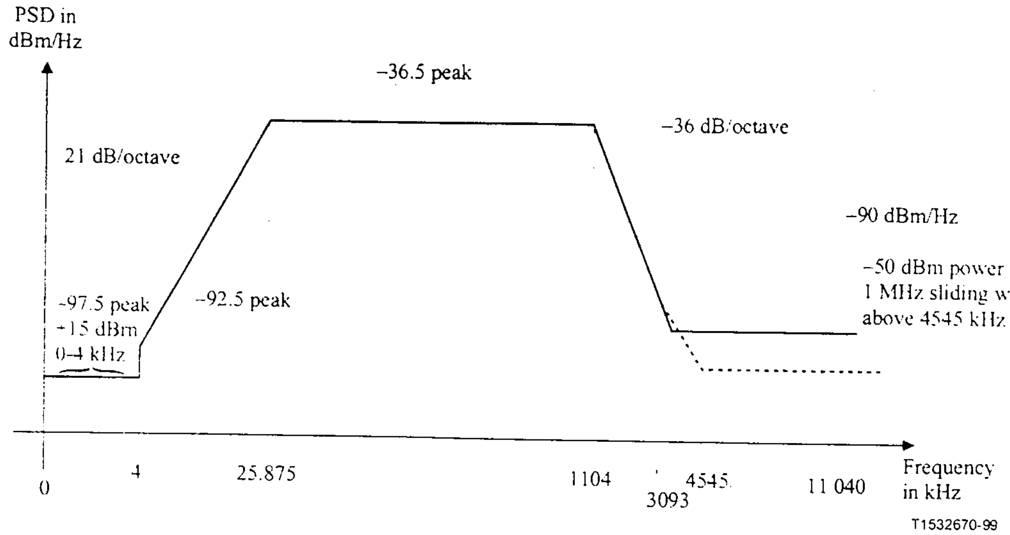
A.1.1 Pilot Frequency (supplements 7.11.1.2)

The downstream pilot frequency shall be 276 kHz; that is, $n_{C\text{-}PILOT} = 64$.

A.1.2 ATU-C downstream transmit spectral mask (replaces 7.14)

The band from 25 to 1104 kHz that is referred to is the widest possible band (used for ADSL over POTS implemented with overlapped spectrum). Limits defined within this band apply also to any narrower bands used.

Figure A.1 shows a representative spectral mask for the transmit signal. The low-frequency stop-band is defined as the POTS band, the high-frequency stop-band is defined as frequencies greater than 1104 kHz.



Frequency band f (kHz)	Equation for line (dBm/Hz)
$0 < f < 4$	−97.5, with max power in the in 0-4 kHz band of +15 dBm
$4 < f < 25.875$	$-92.5 + 21 \times \log_2 (f/4)$
$25.875 < f < 1104$	−36.5
$1104 < f < 3093$	$-36.5 - 36 \times \log_2 (f/1104)$
$3093 < f < 4545$	−90 peak, with max power in the $[f, f + 1$ MHz$]$ window of $(-36.5 - 36 \times \log_2 (f/1104) + 60)$ dBm
$4545 < f < 11\,040$	−90 peak, with max power in the $[f, f + 1$ MHz$]$ window of −50 dBm

NOTE 1 – All PSD measurements are in 100 Ω; the POTS band total power measurement is in 600 Ω.

NOTE 2 – The breakpoint frequencies and PSD values are exact; the indicated slopes are approximate.

NOTE 3 – Above 25.875 kHz, the peak PSD shall be measured with a 10 kHz resolution bandwidth.

NOTE 4 – The power in a 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency.

NOTE 5 – The step in the PSD mask at 4 kHz is to protect V.90 performance. Originally, the PSD mask continued the 21 dB/octave slope below 4 kHz hitting a floor of −97.5 dBm/Hz at 3400 Hz. It was recognized that this might impact V.90 performance, and so the floor was extended to 4 kHz.

NOTE 6 – All PSD and power measurements shall be made at the U-C interface (see Figure 1-1); the signals delivered to the PSTN are specified in Annex E.

Figure A.1/G.992.1 – ATU-C transmitter PSD mask

A.1.2.1 Passband PSD and response

The average PSD within the used passband shall be no greater than −40 dBm/Hz reduced by power cut-back (see 10.4.5.1); the lower end of this passband depends on which service and duplexing option is used, and is manufacturer discretionary; the upper end depends on whether the signal is for initialization (see A.1.2.3.1) or steady state (see A.1.2.3.3).

The passband ripple shall be no greater than +3.5 dB; the maximum PSD of $(-40 - 2n_{PCB} + 3.5)$ dBm/Hz applies across the whole band from 25 kHz to 1104 kHz.

The group delay variation over the passband shall not exceed 50 μs.

A.1.2.2 Stop-band PSDs

A.1.2.2.1 Low frequency stop-band rejection

The total power in the voiceband (0 to 4 kHz) shall not exceed +15 dBrn (see Recommendation G.996.1 for the method of measurement).

In the transition band from 4 kHz to 25.875 kHz, the maximum PSD is given by a straight line on a log scale from –92.5 dBm/Hz, at just above 4 kHz, to –36.5 dBm/Hz, at 25.875 kHz; that is $(-92.5 + 21 \times \log(f/4)/\log(2))$ dBm/Hz .

A.1.2.2.2 High frequency stop-band rejection

The PSD shall decrease at a rate greater than or equal to 36 dB/octave from $(-40 + 3.5 - 2n_{PCB})$ dBm/Hz at the band edge (1.104 MHz) to –90 dBm/Hz at 3.093 MHz. Above 3.093 MHz the PSD shall not exceed –90 dBm/Hz. Additionally, there shall be less than –50 dBm of power measured in any 1 MHz sliding window above 4.545 MHz.

A.1.2.3 Transmit power spectral density and aggregate power level

There are three different PSD masks for the ATU-C transmit signal, depending on the type of signal sent. In all cases the power in the voiceband measured at the U-C interface and that is delivered to the Public Switched Telephone Network (PSTN) interface shall conform to the specification in A.1.2.2.1.

The power emitted by the ATU-C is limited by the requirements in this subclause. Notwithstanding these requirements, it is assumed that the ADSL will comply with applicable national requirements on emission of electromagnetic energy.

A.1.2.3.1 All initialization signals (except C-ECT) starting with C-REVERB1

The nominal PSD in the band from 25.875 to 1104 kHz shall be set at –40 dBm/Hz for an aggregate transmit power not greater than 20.4 dBm. If measurement of the upstream power indicates that power cut-back is necessary, then the nominal PSD shall be set to a level of $-40 - 2n_{PCB}$ dBm/Hz (as described in 10.4.5.1).

During the C-REVERB and C-SEGUE signals, all subcarriers from index i to 255 shall be transmitted, with i vendor discretionary (see A.1.2.1). However, at the vendor's discretion, one or more of these subcarriers may not be transmitted during the C-MEDLEY signal.

To allow for non-ideal transmit filter effects (e.g. passband ripple and transition band rolloff), the maximum transmit PSD shall be no more than 1 dB above the nominal PSD level. The maximum transmit PSD shall therefore be no higher than $-39 - 2n_{PCB}$ dBm/Hz.

A.1.2.3.2 C-ECT

Because C-ECT is a vendor defined signal (see 10.4.7), the PSD specification shall be interpreted only as a maximum. This maximum level is $-39 - 2n_{PCB}$ dBm/Hz for the band from 25.875 to 1104 kHz. Subcarriers 1 to 5 may be used, but the power in the voiceband that is delivered to the PSTN interface shall conform to the specification given in A.1.2.2.1.

A.1.2.3.3 Steady-state data signal

The nominal PSD in the band from 25.875 to 1104 kHz shall be set at –40 dBm/Hz. The nominal aggregate power shall be set at $-3.65 + 10\log(ncdown)$ dBm, where *ncdown* is the number of subcarriers used (i.e. with $b_i > 0$) (20.4 dBm if all subcarriers are used). The transmit PSD and aggregate power may, however, be changed from their nominal values in either of the following circumstances:

- A power cut-back may have been applied, reducing the nominal PSD level to $-40 - 2n_{PCB}$ dBm/Hz (see 10.4.5.1).
- The bits and gains table (received from the ATU-R during initialization and possibly updated through bit swaps, see R-B&G in 10.9.14 and 11.2) may not allocate bits to some subcarriers and may finely adjust (i.e. within the range –14.5 to +2.5 dB) the transmit PSD level of others in order to equalize expected error rates on each of those subcarriers.
- Vendor discretionary transmit PSD levels for unused subcarriers (i.e. with $b_i = 0$). The maximum transmit PSD for these subcarriers is specified in b) and c) below.

To allow for non-ideal transmit filter effects (e.g. passband ripple and transition band rolloff), the maximum transmit PSD shall be no more than 1 dB above the finely adjusted nominal PSD level. The maximum transmit PSD shall therefore be no higher than $-36.5 - 2n_{PCB}$ dBm/Hz.

The transmit PSD of each subcarrier is defined as follows:

a) For the subcarriers with ($b_i > 0$), the ATU-C transmitter shall transmit at PSD levels equal to that specified by the g_i (e.g. $g_i = 1$, then transmit at C-MEDLEY transmit PSD level). The aggregate transmit power in these subcarriers shall not exceed $-3.65 + 10\log(ncdown_1) - 2n_{PCB}$ dBm by more than 0.7 dB, where $ncdown_1$ is the number of these subcarriers (i.e. with $b_i > 0$).

b) For the subcarriers with ($b_i = 0$ and $g_i > 0$), the ATU-C transmitter should and is recommended to transmit at PSD levels equal to that specified by the g_i (e.g. $g_i = 1$, then transmit at C-MEDLEY level), with a 4-QAM constellation point (which may change from symbol to symbol). The ATU-R receiver cannot assume any particular PSD levels on those subcarriers. The transmit PSD levels of those subcarriers shall be no higher than the C-REVERB1 transmit PSD level + $10\log(g_i^2)$ dB. The aggregate transmit power in these subcarriers shall not exceed $-3.65 + 10\log(ncdown_2) - 2n_{PCB}$ dBm, where $ncdown_2$ is the number of these subcarriers (i.e. with $b_i = 0$ and $g_i > 0$).

c) For the subcarriers with ($b_i = 0$ and $g_i = 0$), the ATU-C transmitter should and is recommended to transmit no power on those subcarriers. The ATU-R receiver cannot assume any particular PSD levels on those subcarriers. The transmit PSD levels of those subcarriers with $g_i = 0$ shall be at least 10 dB below the sync symbol reference transmit PSD level if the subcarrier is below the lowest used subcarrier (lowest i with $b_i > 0$) and shall be below the sync symbol reference transmit PSD level if the subcarrier is above the lowest used subcarrier.

The aggregate transmit power over the 25.875 to 1104 kHz band shall be no higher than $20.4 - 2n_{PCB}$ dBm, which is equivalent to an average transmit PSD of no higher than $-40 - 2n_{PCB}$ dBm/Hz.

It is recommended that the g_i values for subcarriers with $g_i > 0$ are constraint within ±2.5 dB with respect to g_{sync}, during initialization and subsequent bit swaps, to avoid cyclostationary interference from the synchronization symbol.

A.1.2.3.4 Synchronization symbol

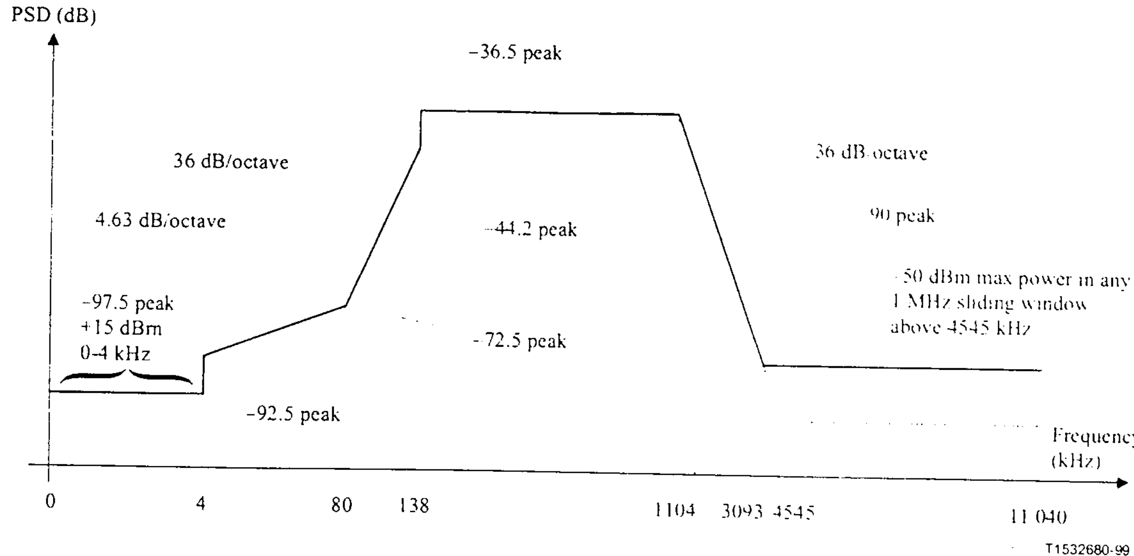
At initialization time, the sync symbol reference transmit PSD level shall be set at $-40 - 2n_{PCB} + 10\log(g_{sync}^2)$ dBm/Hz, with g_{sync}^2 defined as the average g_i^2 value over the used (i.e. $b_i > 0$) subcarriers. The sync symbol reference transmit PSD shall not be updated with used subcarrier gain changes during SHOWTIME.

The transmit PSD level for those subcarriers with $g_i > 0$ shall be the sync symbol reference transmit PSD level. The transmit PSD levels of those subcarriers with $g_i = 0$ shall be at least 10 dB below the sync symbol reference transmit PSD level if the subcarrier is below the lowest used subcarrier (lowest i with $b_i > 0$) and shall be below the sync symbol reference transmit PSD level if the subcarrier is above the lowest used subcarrier.

Since the g_i are applied only to the data symbols, the transmit PSD of a synchronization symbol differs from the transmit PSD of a data symbol. These g_i are calculated for the multipoint constellations in order to equalize the expected error rate on all subcarriers, and are therefore irrelevant for most of the 4-QAM modulated subcarriers of the synchronization symbol.

A.1.3 ATU-C transmitter PSD mask for reduced NEXT

Figure A.2 defines a spectral mask for the ATU-C transmitted signal, which results in reduced NEXT into the ADSL upstream band, relative to the mask in A.1.2. Adherence to this mask will in many cases result in improved upstream performance of the other ADSL systems in the same or adjacent binder group, with the improvement dependent upon the other interferers. This mask differs from the mask in A.1.2 only in the band from 4 kHz to 138 kHz.



Frequency band f (kHz)	Equation for line (dBm/Hz)
$0 < f < 4$	–97.5, with max power in the in 0-4 kHz band of +15 dBm
$4 < f < 80$	$-92.5 + 4.63 \times \log_2 (f/4)$
$80 < f < 138$	$-72.5 + 36 \times \log_2 (f/80)$
$138 < f < 1104$	–36.5
$1104 < f < 3093$	$-36.5 - 36 \times \log_2(f/1104)$
$3093 < f < 4545$	–90 peak, with max power in the $[f, f + 1$ MHz$]$ window of $(-36.5 - 36 \times \log_2(f/1104) + 60)$ dBm
$4545 < f < 11\,040$	–90 peak, with max power in the $[f, f + 1$ MHz$]$ window of –50 dBm

NOTE 1 – All PSD measurements are in 100 Ω; the POTS band total power measurement is in 600 Ω.

NOTE 2 – The breakpoint frequencies and PSD values are exact; the indicated slopes are approximate.

NOTE 3 – Above 25.875 kHz, the peak PSD shall be measured with a 10 kHz resolution bandwidth.

NOTE 4 – The power in a 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency.

NOTE 5 – The step in the PSD mask at 4 kHz is to protect V.90 performance. Originally, the PSD mask continued the 21 dB/octave slope below 4 kHz hitting a floor of –97.5 dBm/Hz at 3400 Hz. It was recognized that this might impact V.90 performance, and so the floor was extended to 4 kHz.

NOTE 6 – All PSD and power measurements shall be made at the U-C interface (see Figure 1-1); the signals delivered to the PSTN are specified in Annex E.

Figure A.2/G.992.1 – ATU-C transmitter PSD mask for reduced NEXT

A.2 ATU-R (see clause 8)

A.2.1 Modulation by the inverse discrete Fourier transform (see 8.11.2)

The modulating transform defines the relationship between the 64 real values x_n and the Z_i

$$x_n = \sum_{i=0}^{63} \exp\left(\frac{j\pi ni}{32}\right) Z_i \qquad \text{(A-1)}$$

The encoder and scaler generate only 31 complex values of Z_i (plus zero at DC and one real value if the Nyquist frequency is used). In order to generate real values of x_n, these values shall be augmented so that the vector Z has Hermitian symmetry. That is,

$$Z_i = conj[Z_{64-i}] \text{ for } i = 33 \text{ to } 63 \qquad \text{(A-2)}$$

A.2.2 Synchronization symbol (supplements 8.11.3)

The data pattern used in the synchronization symbol shall be the pseudo-random sequence PRU (d_n, for n = 1 to 64), defined by:

$$d_n = 1 \qquad \text{for } n = 1 \text{ to } 6 \qquad \text{(A-3)}$$

$$d_n = d_{n-5} \oplus d_{n-6} \qquad \text{for } n = 7 \text{ to } 64 \qquad \text{(A-4)}$$

The bits are used as follows: the first pair of bits (d_1 and d_2) is used for the DC and Nyquist subcarriers (the power assigned to them is, of course, zero, so the bits are effectively ignored); then the first and second bits of subsequent pairs shall be used to define the X_i and Y_i for i = 1 to 31 as shown in Table 7-13.

The period of PRU is only 63 bits, so $d_{64} = d_1$.

The d_1-d_{96} are re-initialized for each symbol, so each symbol of R-REVERB1 uses the same data.

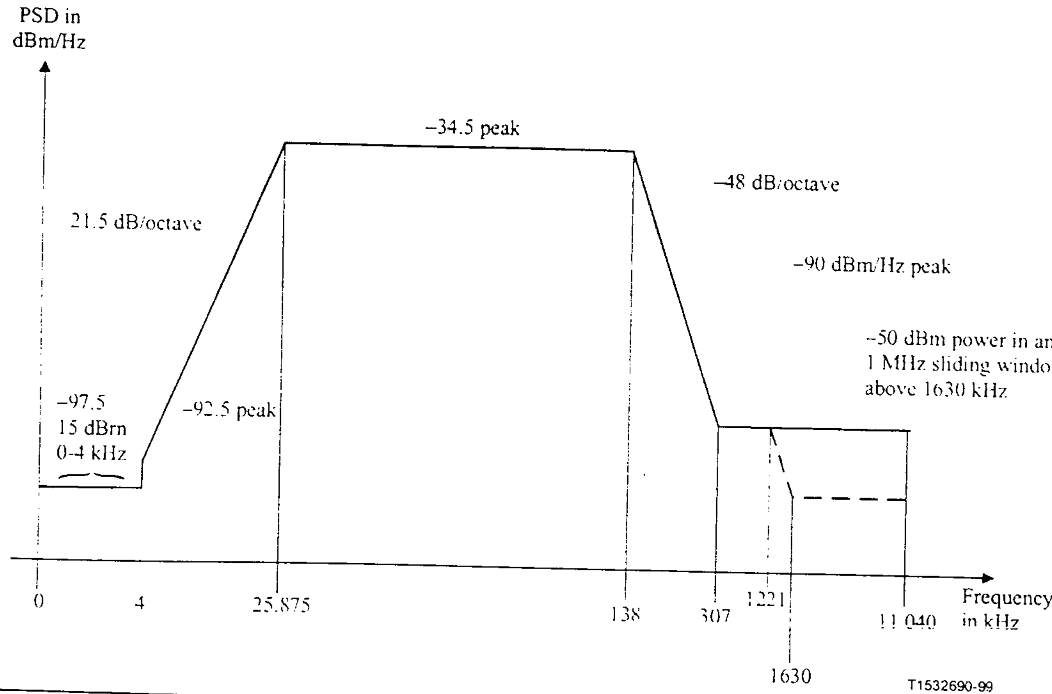
A.2.3 Cyclic prefix (replaces 8.12)

The cyclic prefix shall be used for all symbols beginning with segment C-REVERB3 of the initialization sequence, as defined in 10.7.2.

The last 4 samples of the output of the IDFT (x_k for k = 60 to 63) shall be prepended to the block of 64 samples and read out to the DAC in sequence. That is, the subscripts, k, of the DAC samples in sequence are 60...63, 0...63.

A.2.4 ATU-R transmitter spectral mask (replaces 8.14)

Figure A.3 shows a PSD mask for the transmitted signal. The passband is defined as frequency range over which the modem transmits, which may be narrower than the 25.875 to 138 kHz shown. The low-frequency stop-band is defined as the voiceband.



Frequency band f (kHz)	Equation for line (dBm/Hz)
$0 < f < 4$	–97.5, with max power in the in 0-4 kHz band of +15 dBrn
$4 < f < 25.875$	$-92.5 + 21.5 \times \log_2(f/4)$
$25.875 < f < 138$	–34.5
$138 < f < 307$	$-34.5 - 48 \times \log_2(f/138)$
$307 < f < 1221$	–90
$1221 < f < 1630$	–90 peak, with max power in the $[f, f + 1$ MHz$]$ window of $(-90 - 48 \times \log_2(f/1221) + 60)$ dBm
$1630 < f < 11\,040$	–90 peak, with max power in the $[f, f + 1$ MHz$]$ window of –50 dBm

NOTE 1 – All PSD measurements are in 100 Ω; the POTS band total power measurement is in 600 Ω.

NOTE 2 – The breakpoint frequencies and PSD values are exact; the indicated slopes are approximate.

NOTE 3 – Above 25.875 kHz, the peak PSD shall be measured with a 10 kHz resolution bandwidth.

NOTE 4 – The power in a 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency.

NOTE 5 – The step in the PSD mask at 4 kHz is to protect V.90 performance. Originally, the PSD mask continued the 21.5 dB/octave slope below 4 kHz hitting a floor of –97.5 dBm/Hz at 3400 Hz. It was recognized that this might impact V.90 performance, and so the floor was extended to 4 kHz.

NOTE 6 – All PSD and power measurements shall be made at the U-C interface (see Figure 1-1); the signals delivered to the PSTN are specified in Annex E.

Figure A.3/G.992.1 – ATU-R transmitter PSD mask

A.2.4.1 Passband PSD and response

The average PSD within the used passband shall be no greater than –38 dBm/Hz; the upper end of this passband depends on whether the signal is for initialization (see A.2.4.3.1) or steady state (see A.2.4.3.3).

The passband ripple shall be no greater than +3.5 dB; the maximum PSD of –34.5 dBm/Hz applies across the whole band from 25 kHz to 138 kHz.

The group delay variation over the passband shall not exceed 50 μs.

The transmit PSD of each subcarrier is defined as follows:

a) For the subcarriers with ($b_i > 0$), the ATU-R transmitter shall transmit at PSD levels equal to that specified by the g_i (e.g. $g_i = 1$, then transmit at R-MEDLEY transmit PSD level). The aggregate transmit power in these subcarriers shall not exceed $-1.65 + 10\log(ncup_1)$ dBm by more than 0.7 dB, where $ncup_1$ is the number of these subcarriers (i.e. with $b_i > 0$).

b) For the subcarriers with ($b_i = 0$ and $g_i > 0$), the ATU-R transmitter should and is recommended to transmit at PSD levels equal to that specified by the g_i (e.g. $g_i = 1$, then transmit at R-MEDLEY level), with a 4-QAM constellation point (which may change from symbol to symbol). The ATU-C receiver cannot assume any particular PSD levels on those subcarriers. The transmit PSD levels of those subcarriers shall be no higher than the R-REVERB1 transmit PSD level + $10\log(g_i^2)$ dB. The aggregate transmit power in these subcarriers shall not exceed $-1.65 + 10\log(ncup_2)$ dBm, where $ncup_2$ is the number of these subcarriers (i.e. with $b_i = 0$ and $g_i > 0$).

c) For the subcarriers with ($b_i = 0$ and $g_i = 0$), the ATU-R transmitter should and is recommended to transmit no power on those subcarriers. The ATU-C receiver cannot assume any particular PSD levels on those subcarriers. The transmit PSD levels of those subcarriers with $g_i = 0$ shall be at least 10 dB below the sync symbol reference transmit PSD level if the subcarrier is below the lowest used subcarrier (lowest i with $b_i > 0$) and shall be below the sync symbol reference transmit PSD level if the subcarrier is above the lowest used subcarrier.

The aggregate transmit power over the 25.875 to 138 kHz band shall be no higher than 12.5 dBm, which is equivalent to an average transmit PSD of no higher than –38 dBm/Hz.

It is recommended that the g_i values for subcarriers with $g_i > 0$ are constraint within ±2.5 dB with respect to g_{sync}, during initialization and subsequent bit swaps, to avoid cyclostationary interference from the synchronization symbol.

A.2.4.3.4 Synchronization symbol

At initialization time, the sync symbol reference transmit PSD level shall be set at $-38 + 10\log(g_{sync}^2)$ dBm/Hz , with g_{sync}^2 defined as the average g_i^2 value over the used (i.e. $b_i > 0$) subcarriers. The sync symbol reference transmit PSD shall not be updated with used subcarrier gain changes during SHOWTIME.

The transmit PSD level for those subcarriers with $g_i > 0$ shall be the sync symbol reference transmit PSD level. The transmit PSD levels of those subcarriers with $g_i = 0$ shall be at least 10 dB below the sync symbol reference transmit PSD level if the subcarrier is below the lowest used subcarrier (lowest i with $b_i > 0$) and shall be below the sync symbol reference transmit PSD level if the subcarrier is above the lowest used subcarrier.

Since the g_i are applied only to the data symbols, the transmit PSD of a synchronization symbol differs from the transmit PSD of a data symbol. These g_i are calculated for the multipoint constellations in order to equalize the expected error rate on all subcarriers, and are therefore irrelevant for most of the 4-QAM modulated subcarriers of the synchronization symbol.

A.2.5 Nyquist frequency (supplements 8.11.1.2)

The upstream Nyquist frequency shall be at subcarrier #32 ($f = 138$ kHz).

A.3 Initialization (see clause 10)

A.3.1 Power cut-back (supplements 10.4.5.1)

If the total upstream power measured on subcarriers 7-18 during R-REVERB1 is greater than 3 dBm, then the PSD for C-REVERB1 and all subsequent downstream signals shall be as shown in Table A.1.

Table A.1/G.992.1 – Power cut-back: downstream PSD as a function of upstream received power

Upstream received power (dBm) <	3	4	5	6	7	8	9
Max downstream PSD (dBm/Hz)	–40	–42	–44	–46	–48	–50	–52

This chosen level shall become the reference level for all subsequent gain calculations.

A.3.2 Estimated average upstream loop attenuation (see 10.8.9.1)

With the allowable transmit PSDs –38 dBm/Hz over the 25.875 to 138 kHz band, the total transmit power, as used for this calculation, shall be 12.5 dBm.

A.3.3 Estimated average downstream loop attenuation (supplements 10.9.8.1)

With the allowable transmit PSDs as defined in Table 10-7 (–40 dBm/Hz to –52 dBm/Hz) and a maximum bandwidth of approximately 1074 kHz if using overlapped spectrum, the total transmit power, as used for this calculation, may range from a maximum of 20.3 dBm in steps of –2 dB to a minimum of 8.3 dBm.

A.3.4 C-PILOT1 (supplements 10.4.2)

$f_{C\text{-}PILOT1}$ = 276 kHz that is, $N_{C\text{-}PILOT1}$ = 64.

A.3.5 R-REVERB1 (see 10.5.2)

The data pattern used in R-REVERB1 is the pseudo-random upstream sequence PRU defined in A.2.2 and repeated here for convenience:

$$d_n = 1 \qquad \text{for } n = 1 \text{ to } 6 \tag{A-5}$$

$$d_n = d_{n-5} \oplus d_{n-6} \qquad \text{for } n = 7 \text{ to } 64 \tag{A-6}$$

The bits defined in 10.5.2 shall be used as follows: the first pair of bits (d_1 and d_2) is used for the DC and Nyquist subcarriers (the power assigned to them is, of course, zero, so the bits are effectively ignored); then the first and second bits of subsequent pairs are used to define the X_i and Y_i for i = 1 to 31 as defined for C-REVERB1 in Table 7-13. Although data bits are defined for all the subcarriers, the subcarriers actually transmitted during R-REVERB1 start from a vendor discretionary subcarrier index (see A.2.4.3.1). No gain scaling shall be applied to any subcarrier.

A.3.6 C-ECT (see 10.4.7)

The level of the ADSL signal in the frequency band from 0 to about 10 kHz that leaks through the POTS low-pass filter is tightly limited (see 7.14). Therefore it is recommended that subcarriers 1-4 not be used for C-ECT, or, at least, that they be transmitted at a much lower level.

A.3.7 R-ECT (see 10.5.4)

The level of the ADSL signal in the frequency band from 0 to about 10 kHz that leaks through the POTS low-pass filter is tightly limited (see Annex E). Therefore it is recommended that subcarriers 1-4 not be used for R-ECT, or, at least, that they be transmitted at a much lower level.

A.3.8 C-MSG2 (supplements 10.8.9)

$n_{1C\text{-}MSG2} = 43$

$n_{2C\text{-}MSG2} = 91$

A.3.9 R-MSG2 (supplements 10.9.8)

$N_{1R\text{-}MSG2} = 10$

$N_{2R\text{-}MSG2} = 20$

A.4 Electrical characteristics (new)

This subclause specifies the combination of ATU-x and high-pass filter, as shown in Figure 1-1; further information about the low-pass filter is specified in Annex E.

A.4.1 DC characteristics

All requirements of this Recommendation shall be met in the presence of all POTS loop currents from 0 mA to 100 mA, and differential loop voltages as follows:

- DC voltages of 0 V to minus 60 V.
- Ringing signals no larger than 103 V rms at any frequency from 20 to 30 Hz with a DC component in the range from 0 V to minus 60 V.
- The input DC resistance of the ATU-x at the U-x interface shall be greater than or equal to 5 MΩ.

NOTE – The most common implementation of the splitter filters is with the low-pass and high-pass connected in parallel at the U-x port. In this arrangement the high-pass filter will typically block DC with capacitors.

A.4.2 Voiceband characteristics

A.4.2.1 Input impedance

The imaginary part of the ATU-x input impedance, as measured at the U-x interface, at 4 kHz shall be in the range of 1.1-2.0 kΩ (approximately equivalent to a 20-34 nF capacitor) for the ATU-R (or the ATU-C that has an integrated splitter and high-pass function) and in the range of 500 Ω to 1.0 kΩ (approximately equivalent to 40-68 nF) for the ATU-C designed to be used with an external splitter. In both cases, the imaginary part of the impedance shall increase monotonically below 4 kHz.

Refer to Annex E for additional information.

A.4.2.2 ADSL noise interference into the POTS circuit

This is the specification for the voiceband PSD of the ATU-C and ATU-R (see 7.14 and 8.14, respectively).

A.4.3 ADSL band characteristics

A.4.3.1 Longitudinal balance

Longitudinal balance at the U-C and U-R interfaces shall be >40 dB over the frequency range 30 kHz to 1104 kHz. If only the HPF part of the POTS splitter is integrated in the ATU, the measurement of the longitudinal balance in the ADSL band shall be performed as shown in Figure A.4. If both the LPF and the HPF parts of the POTS splitter are integrated in the ATU, the measurement of the longitudinal balance in the ADSL band shall be performed with the PSTN and POTS interfaces terminated with ZTC and ZTR, respectively, as shown in Figure A.5. Longitudinal balance is given by the equation:

$$LBal = 20\log\left|\frac{e_l}{e_m}\right| \text{dB} \qquad \text{(A-7)}$$

where:

e_l = the applied longitudinal voltage (referenced to the building or green wire ground of the ATU);

e_m = the resultant metallic voltage appearing across a terminating resistor.

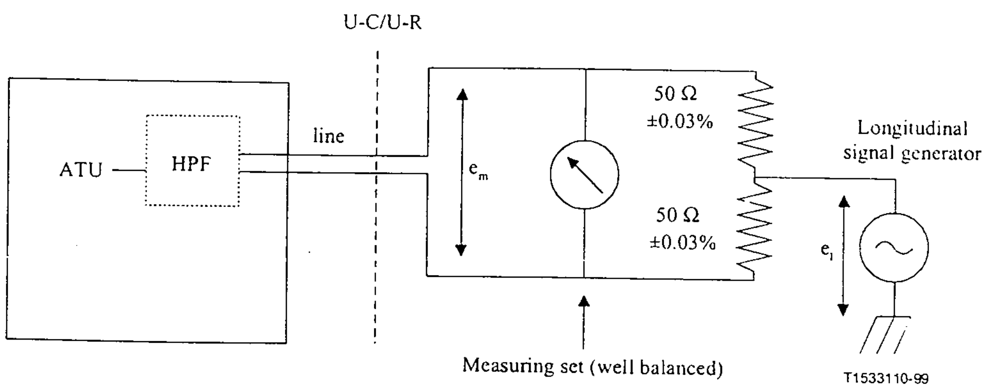


Figure A.4/G.992.1 – Longitudinal balance above 30 kHz measurement method (only HPF integrated)

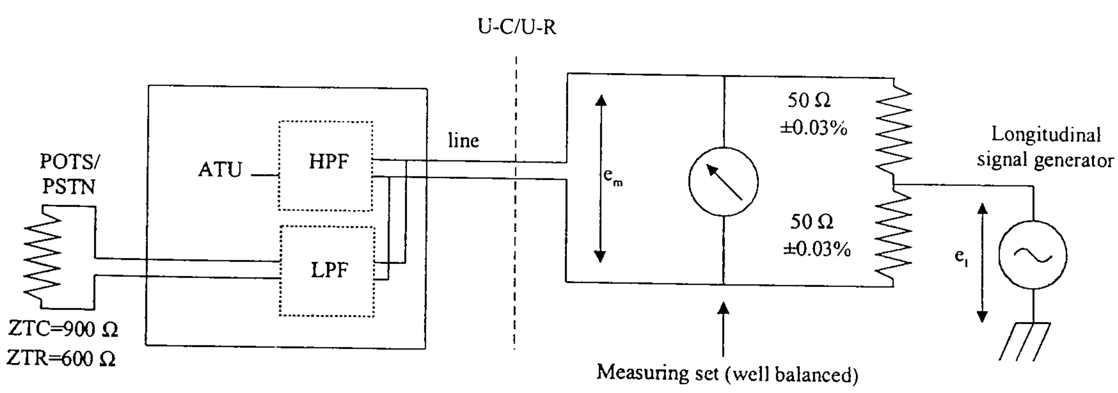


Figure A.5/G.992.1 – Longitudinal balance above 30 kHz measurement method (HPF and LPF integrated)